US006236104B1

(12) **United States Patent**
Falster

(10) **Patent No.: US 6,236,104 B1**
(45) **Date of Patent: *May 22, 2001**

(54) **SILICON ON INSULATOR STRUCTURE FROM LOW DEFECT DENSITY SINGLE CRYSTAL SILICON**

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(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/387,288**

(22) Filed: **Aug. 31, 1999**

Related U.S. Application Data

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(51) **Int. Cl.**[7] **H01L 29/06**; H01L 27/01; H01L 27/12; H01L 31/0392

(52) **U.S. Cl.** **257/618**; 257/347; 257/913

(58) **Field of Search** 257/347, 618, 257/913

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(57) **ABSTRACT**

The present invention relates to a silicon on insulator ("SOI") structure having a low defect density device layer and, optionally, a handle wafer having improved gettering capabilities. The device layer comprises a central axis, a circumferential edge, a radius extending from the central axis to the circumferential edge, and a first axially symmetric region which is substantially free of agglomerated intrinsic point defects. Additionally, the present invention is directed to such a SOI structure which has a Czochralski single crystal silicon handle wafer which is capable of forming an ideal, non-uniform depth distribution of oxygen precipitates upon being subjected to the heat treatment cycles of essentially any arbitrary electronic device manufacturing process.

40 Claims, 35 Drawing Sheets

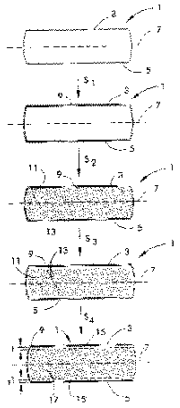

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FIG. 1

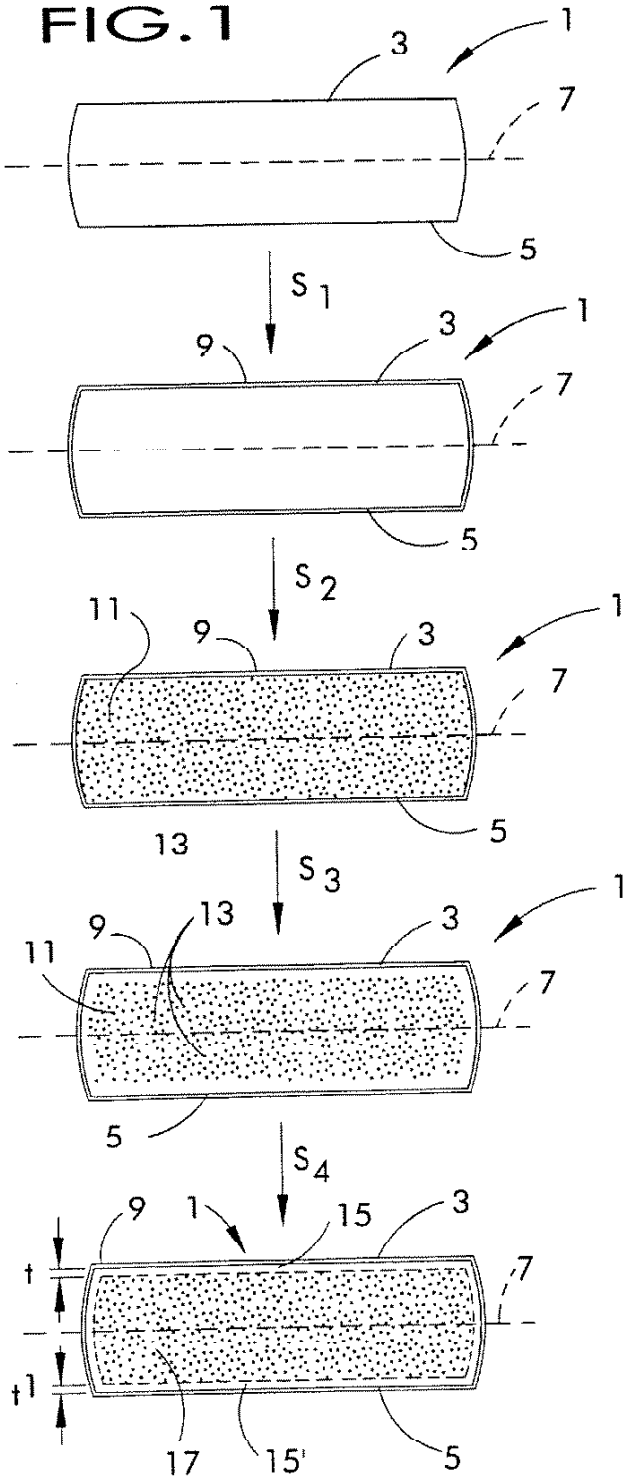


FIG.2

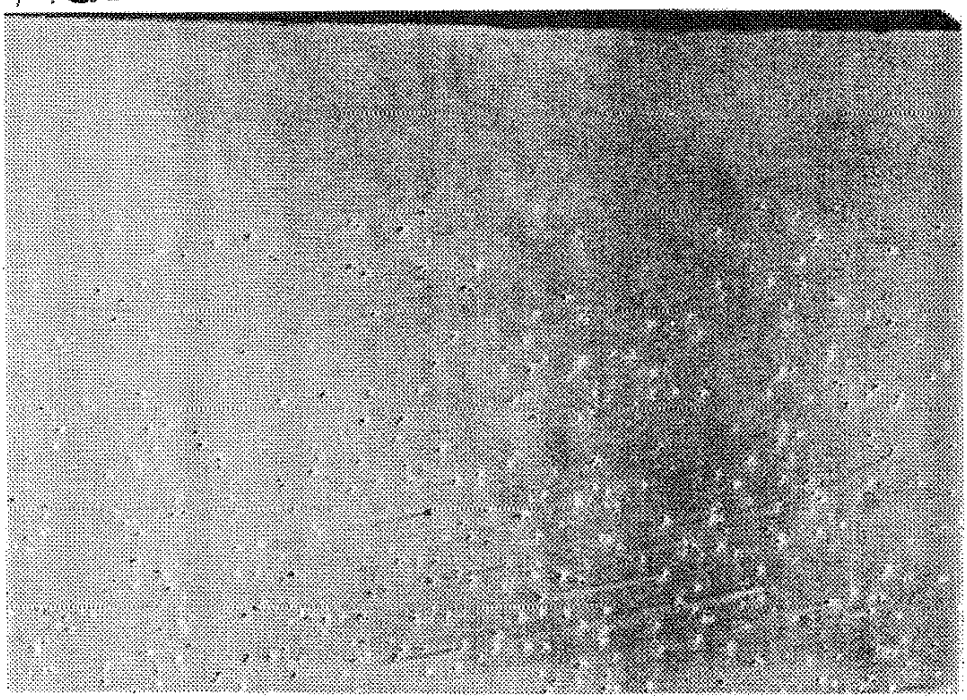


FIG.3

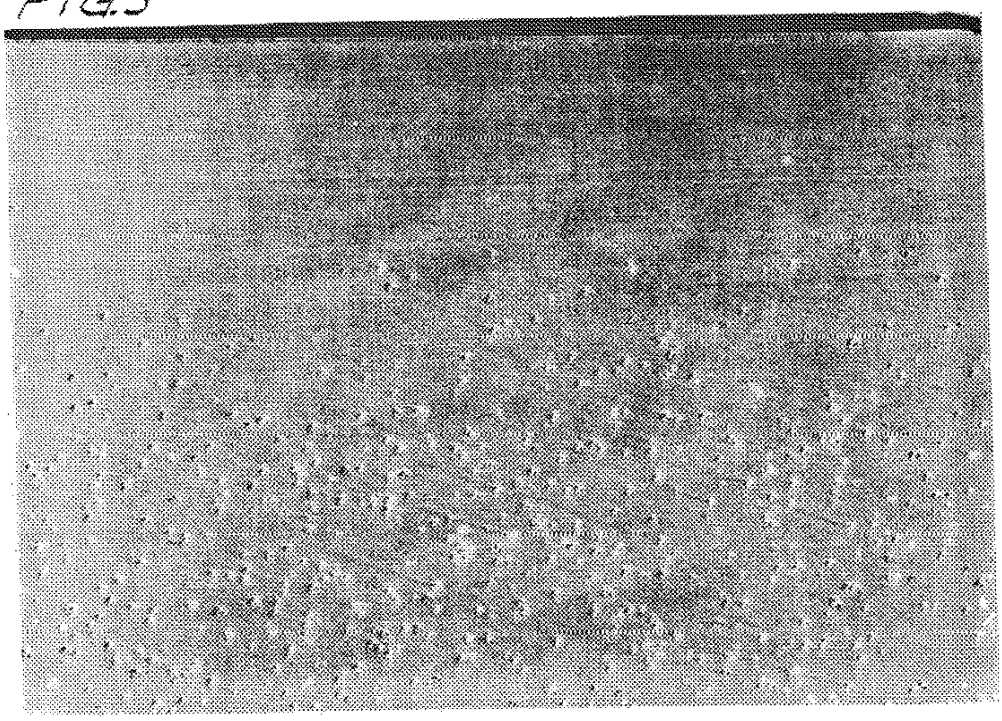


FIG 4

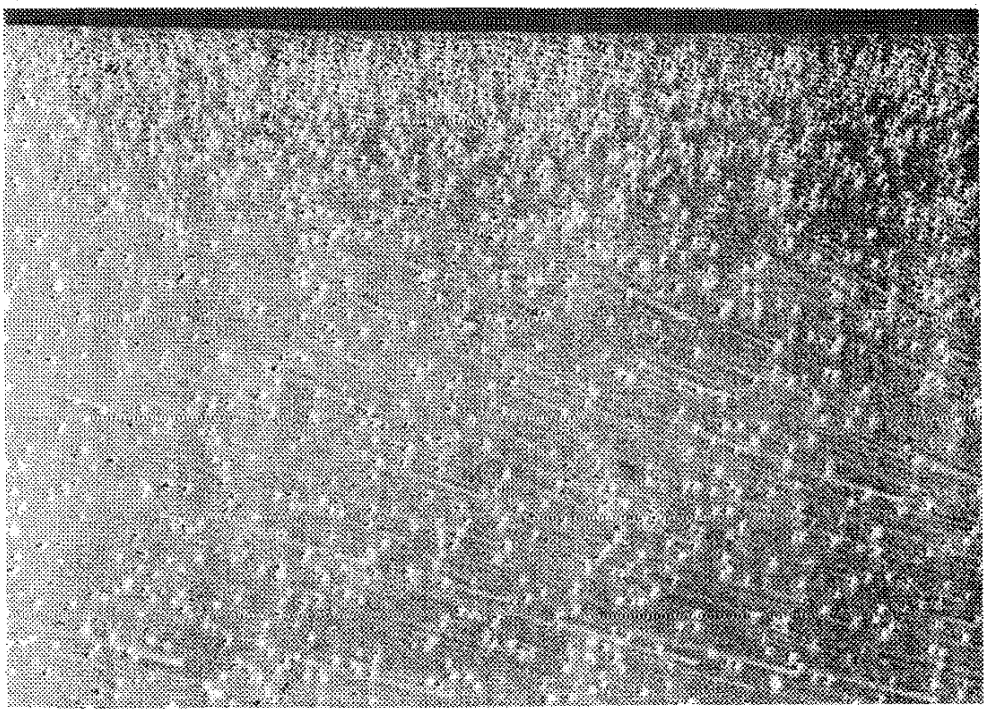


FIG. 5

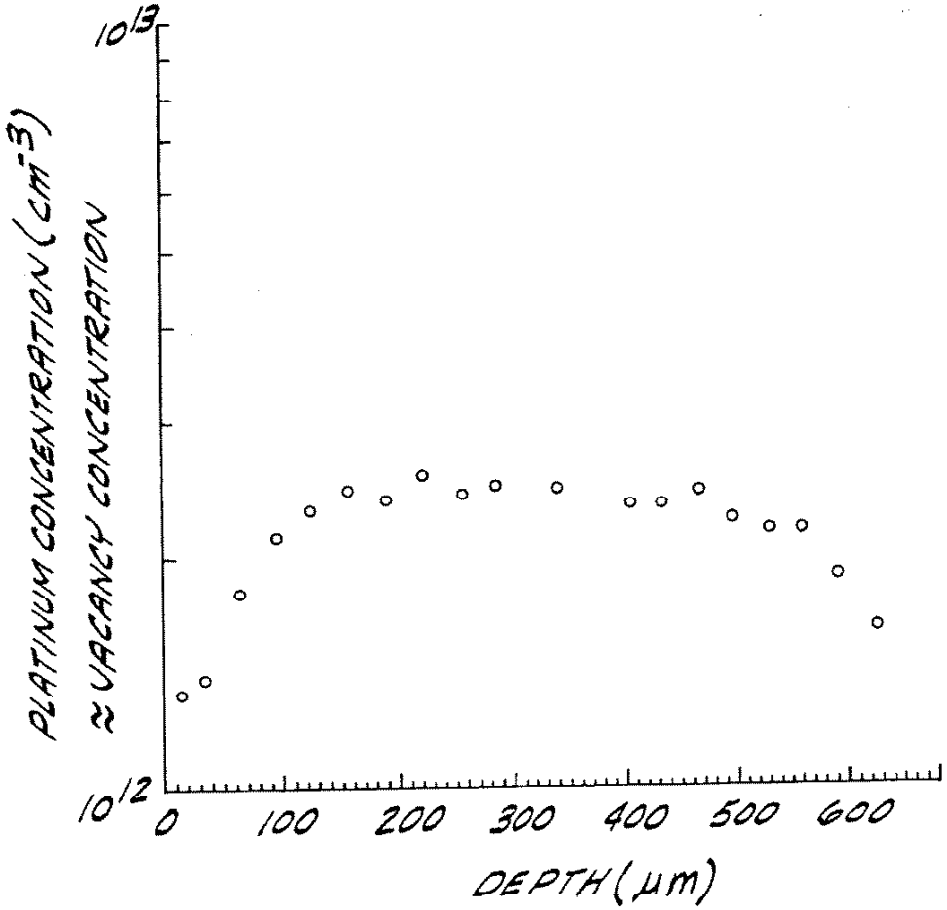

PLATINUM CONCENTRATION (CM-3)
≈ VACANCY CONCENTRATION
10^13
10^12
0
100
200
300
400
500
600
DEPTH (μm)

FIG 6

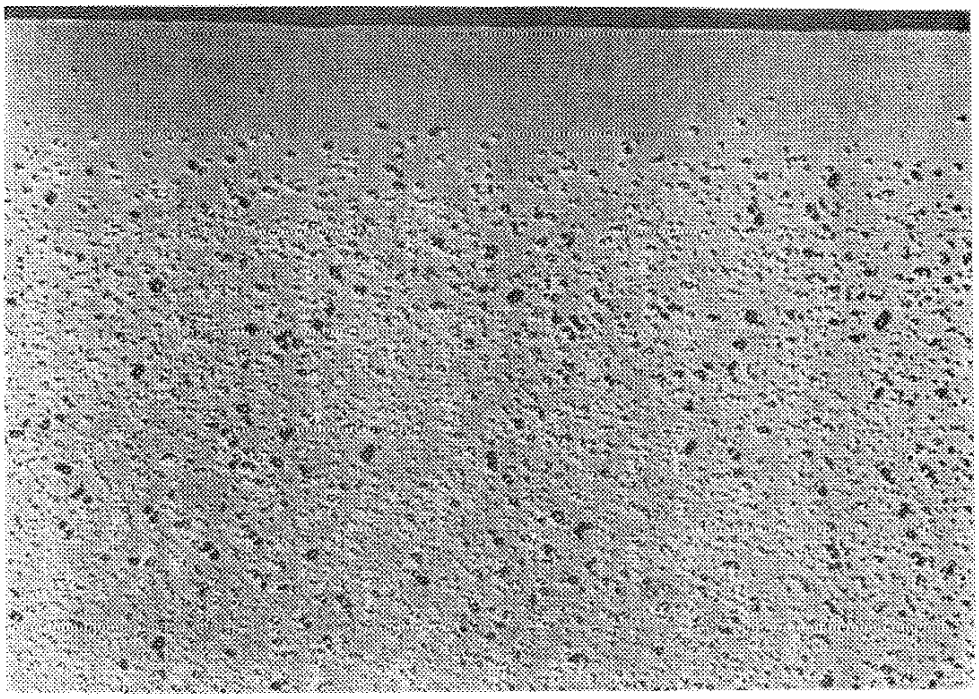


FIG. 7

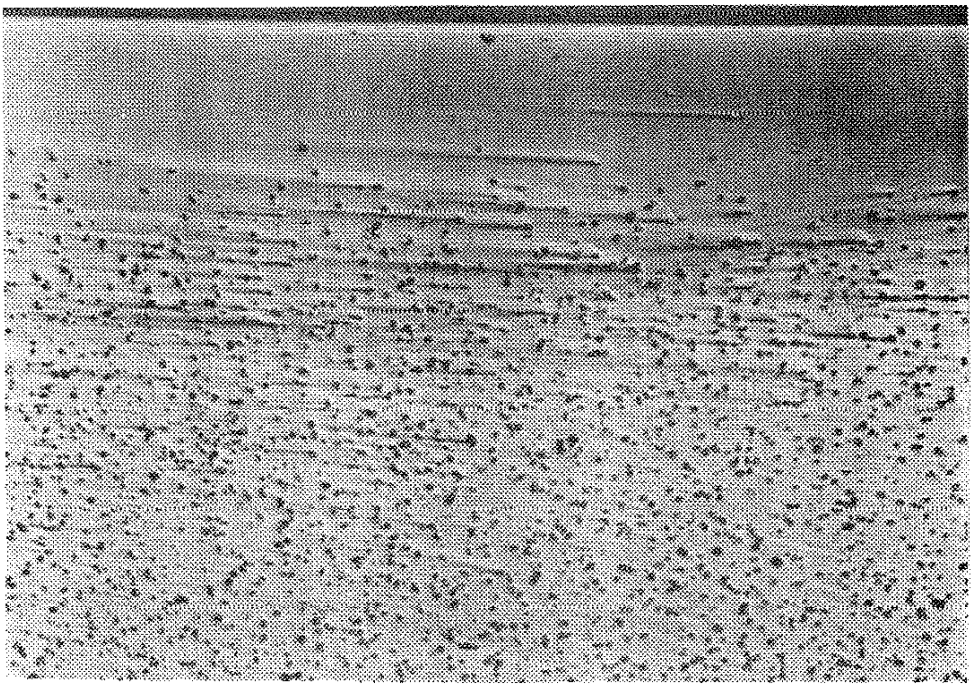


FIG.8

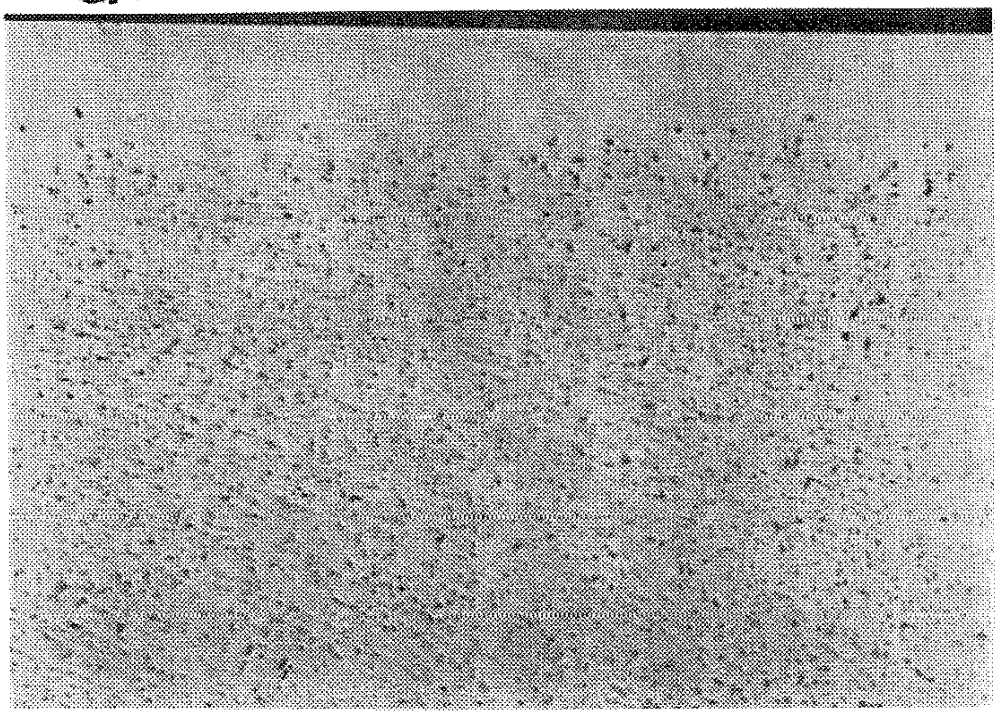


FIG. 9

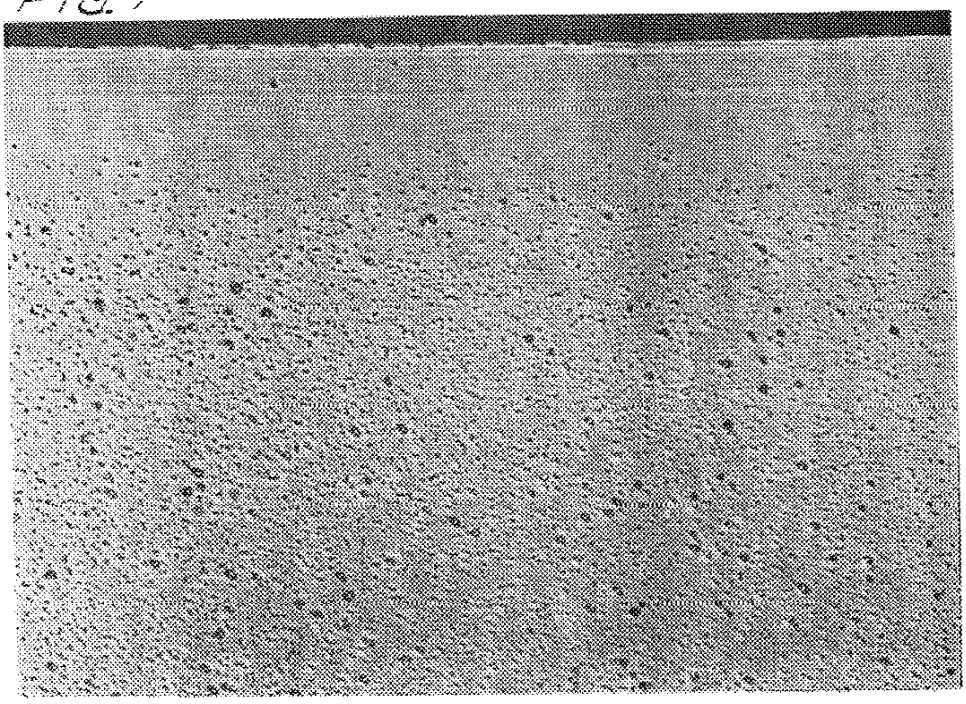


FIG. 10

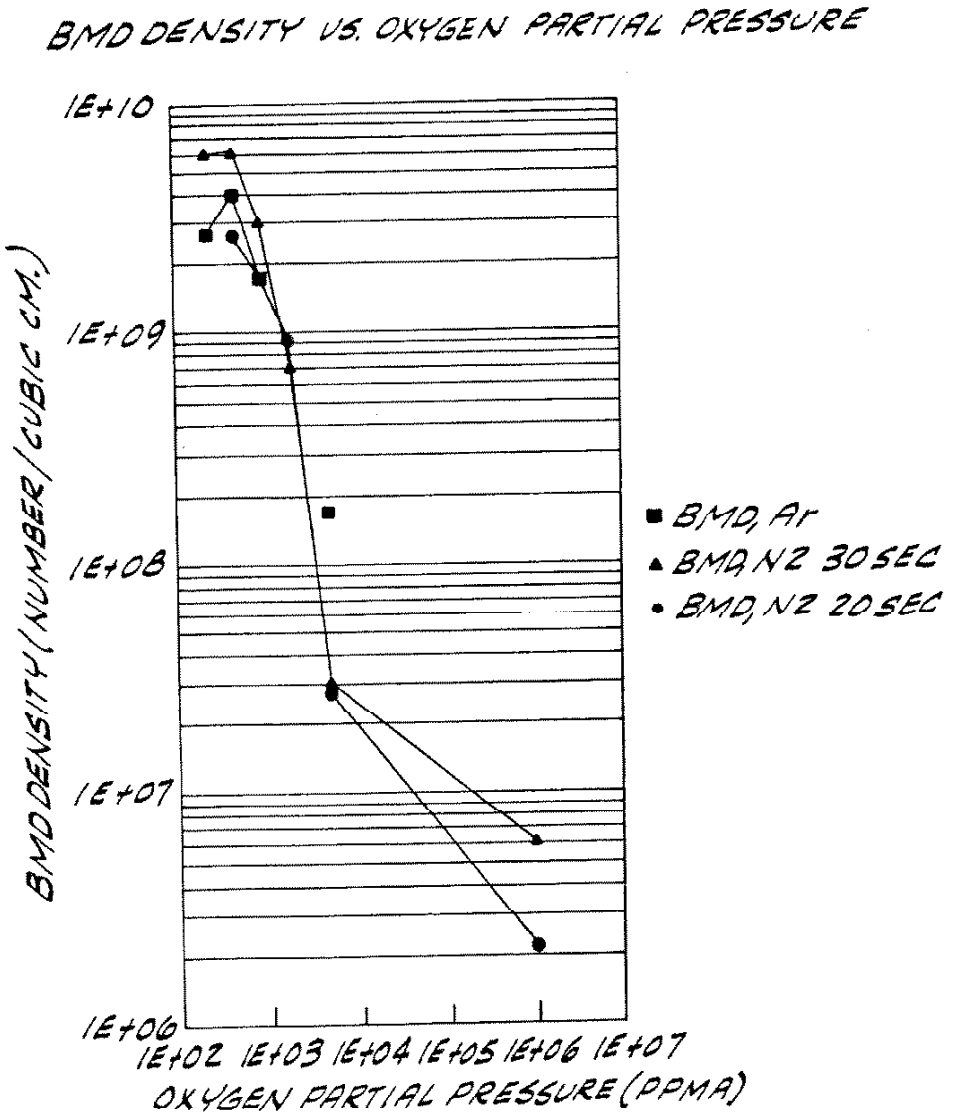

BMD DENSITY VS. OXYGEN PARTIAL PRESSURE
1E+10
1E+09
1E+08
1E+07
1E+06
BMD DENSITY (NUMBER/CUBIC CM.)
1E+02 1E+03 1E+04 1E+05 1E+06 1E+07
OXYGEN PARTIAL PRESSURE (PPMA)
BMD, Ar
BMD, N2 30SEC
BMD, N2 20SEC

FIG.11

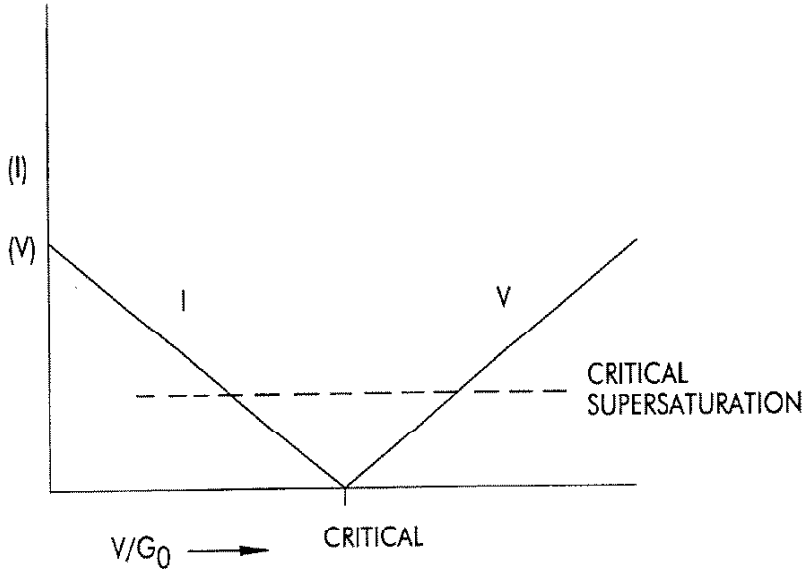

(I)
(V)
I
V
CRITICAL
SUPERSATURATION
V/G0
CRITICAL

FIG.12

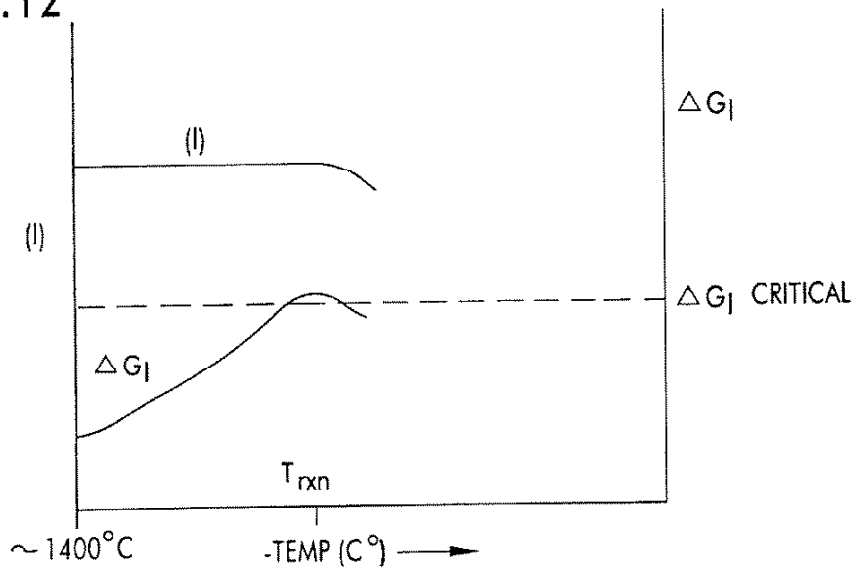

(I)
(I)
ΔGI
ΔGI CRITICAL
ΔGI
Trxn
~1400°C
-TEMP (C°)

FIG.13

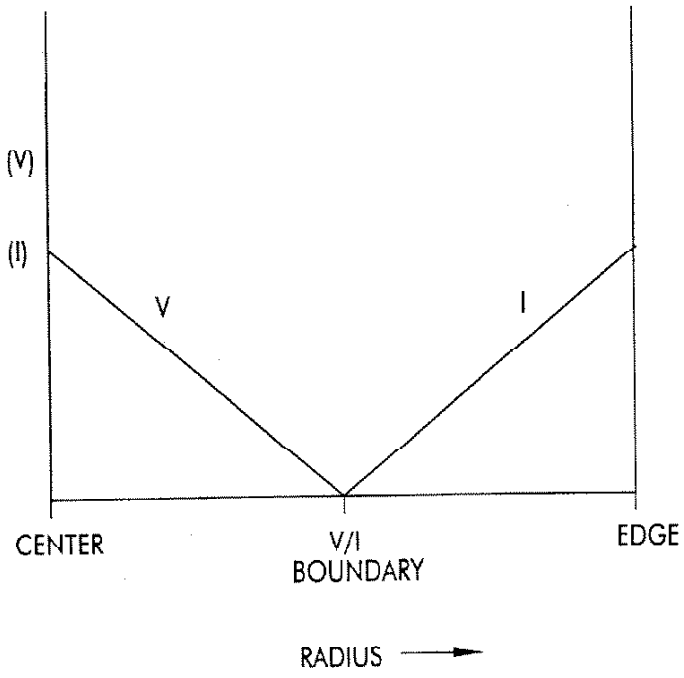

(V)
(I)
V
I
CENTER
V/I
BOUNDARY
EDGE
RADIUS

FIG.14

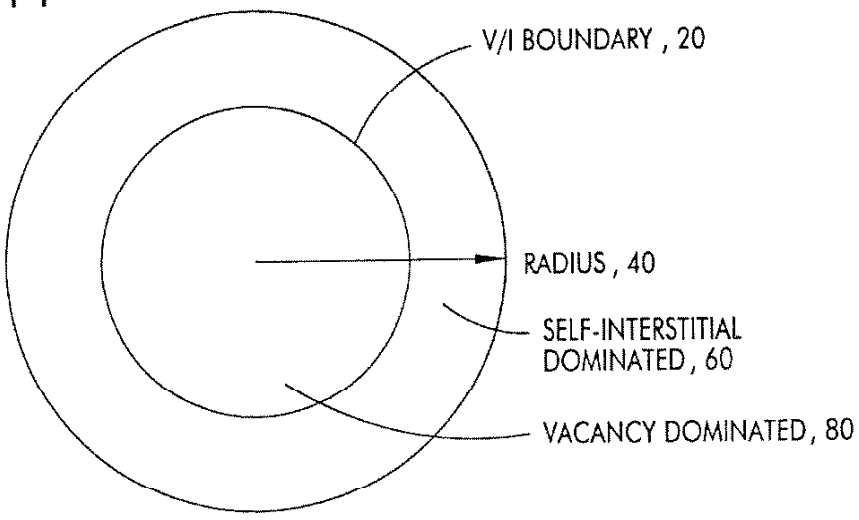

V/I BOUNDARY , 20
RADIUS , 40
SELF-INTERSTITIAL
DOMINATED , 60
VACANCY DOMINATED , 80

FIG.15

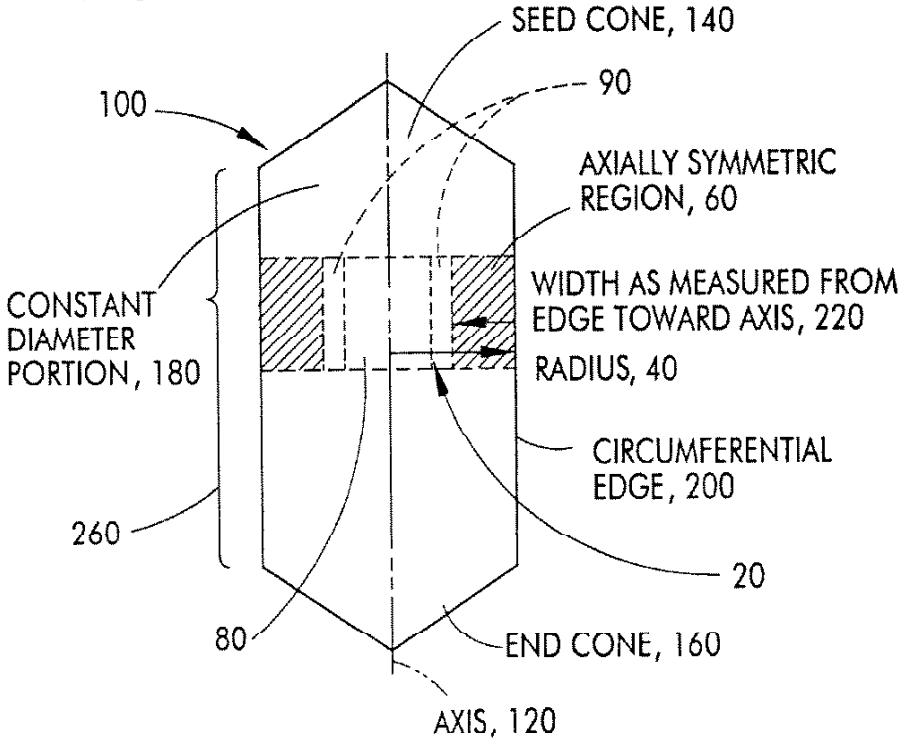
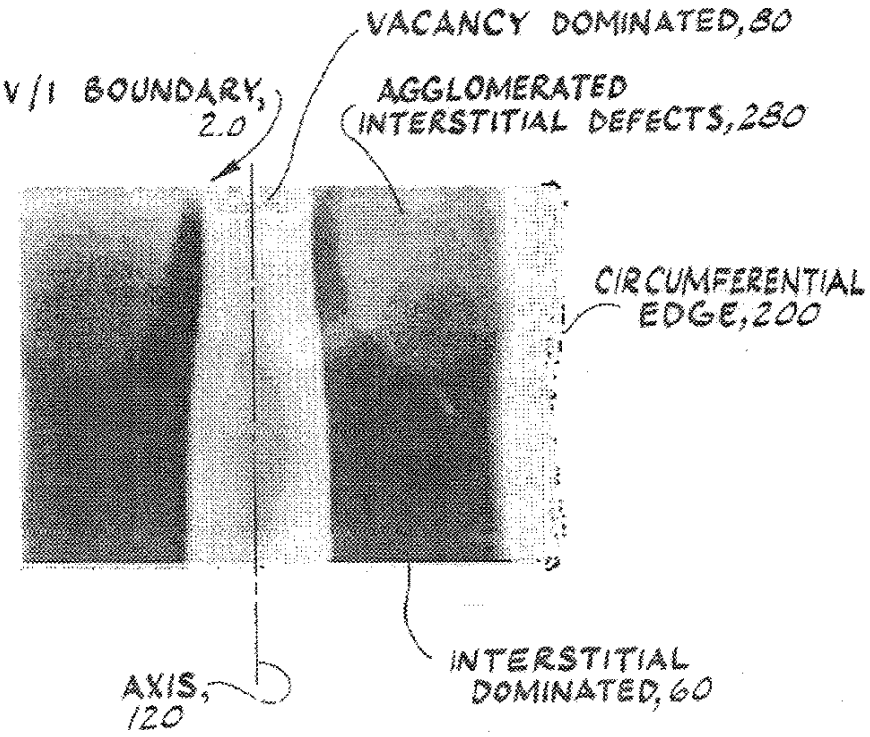

SEED CONE, 140
90
100
AXIALLY SYMMETRIC REGION, 60
WIDTH AS MEASURED FROM EDGE TOWARD AXIS, 220
CONSTANT DIAMETER PORTION, 180
RADIUS, 40
CIRCUMFERENTIAL EDGE, 200
260
20
80
END CONE, 160
AXIS, 120

FIG.16


VACANCY DOMINATED, 80
V/I BOUNDARY, 20
AGGLOMERATED INTERSTITIAL DEFECTS, 280
CIRCUMFERENTIAL EDGE, 200
INTERSTITIAL DOMINATED, 60
AXIS, 120

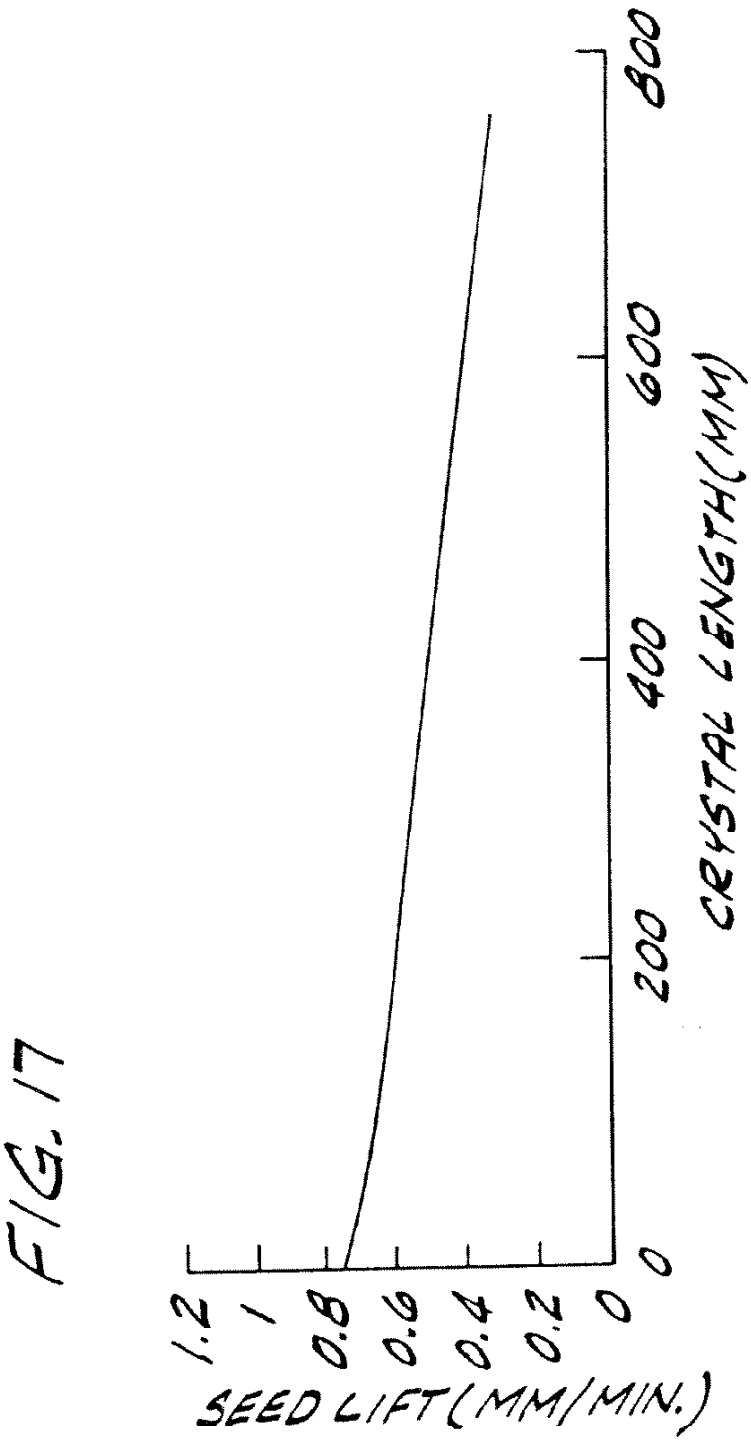

800
600
400
200
0
CRYSTAL LENGTH (MM)
1.2
1
0.8
0.6
0.4
0.2
0
SEED LIFT (MM/MIN.)

FIG. 17

FIG. 18

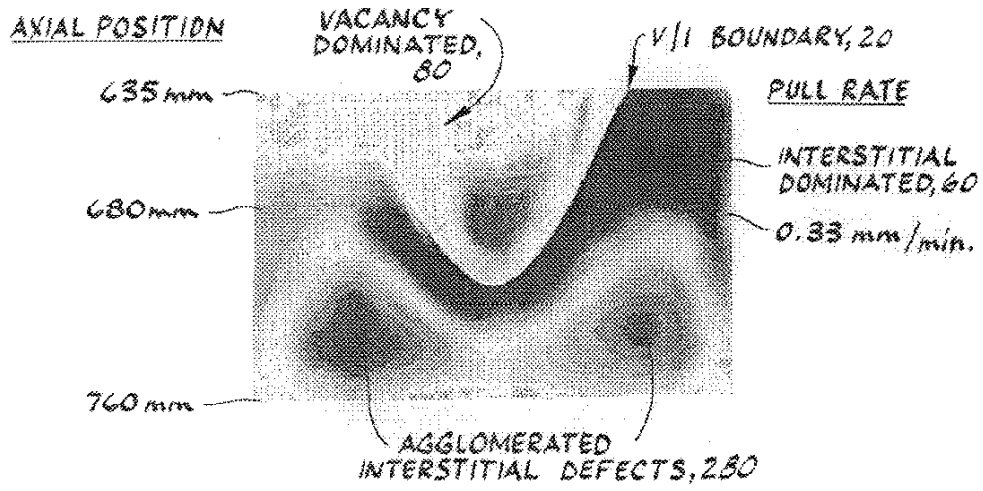
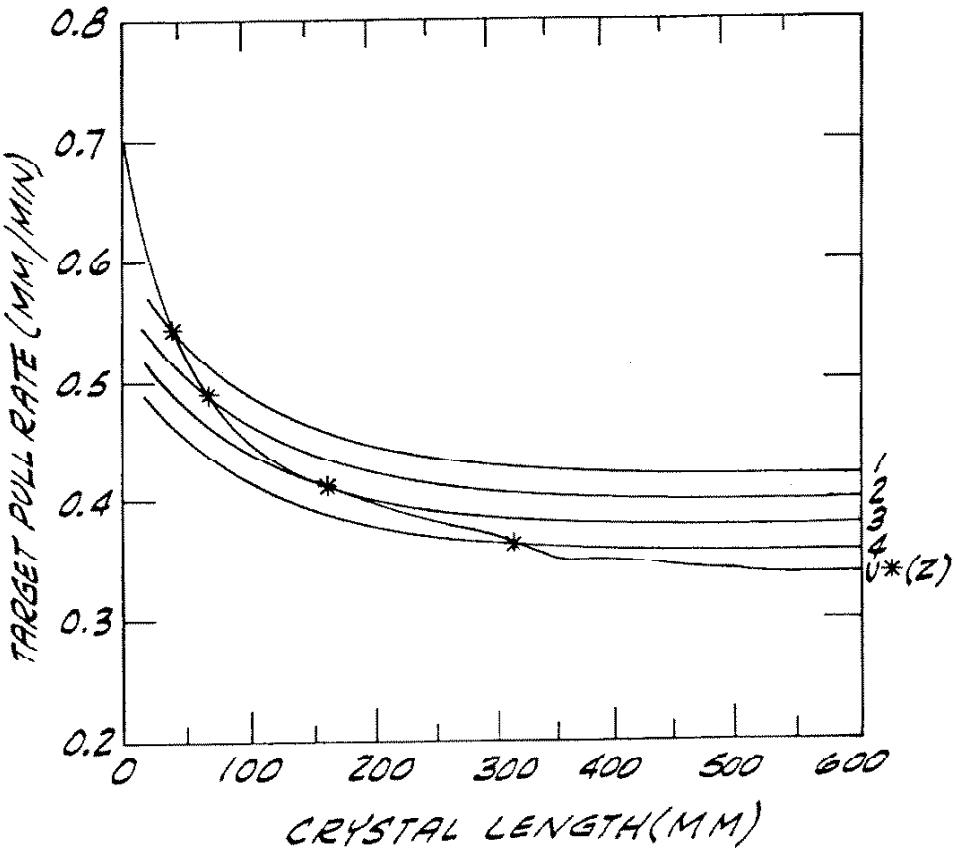

AXIAL POSITION
VACANCY DOMINATED, 80
V/I BOUNDARY, 20
PULL RATE
635 mm
INTERSTITIAL DOMINATED, 60
680 mm
0.33 mm/min.
760 mm
AGGLOMERATED INTERSTITIAL DEFECTS, 250

FIG. 19


0.8
0.7
0.6
0.5
0.4
0.3
0.2
TARGET PULL RATE (MM/MIN)
0
100
200
300
400
500
600
CRYSTAL LENGTH(MM)
1
2
3
4
V*(Z)